EARTH SURFACE PROCESSES AND LANDFORMS, VOL. 21, 479–481 (1996)

SHORT COMMUNICATION

REPLY: APPLICATION OF THE QDa–Md METHOD OF ENVIRONMENTAL DISCRIMINATION TO PARTICLE SIZE ANALYSES OF FINE SEDIMENTS BY PIPETTE AND SEDIGRAPH METHODS

R. W. DUCK

Department of Geography, University of Dundee, Dundee, DD1 4HN, UK

Received 27 June 1995
Accepted 25 September 1995

ABSTRACT

Although it may be inappropriate to apply the QDa–Md method to grain-size distribution data of bimodal and polymodal sediments, the aim of the study (R. W. Duck, *Earth Surface Processes and Landforms*, 1994, **19**, 525–529) was not to defend this methodology. It was to determine whether or not the modern SediGraph yielded particle size data, for a suite of fine-grained, 'quiet water' sediments, which are accommodated by the appropriate QDa–Md trend envelopes, originally established on the basis of the pipette method. That this was shown to be the case, despite the considerable differences in the values of QDa and Md recorded in comparative analyses, demonstrates the applicability of the method to SediGraph-derived data for fine-grained sediments and in no way invalidates the approach adopted.

KEY WORDS particle size analysis; pipette method; SediGraph; QDa–Md method

I welcome the discussion of my recent paper (Duck, 1994) by Woolfe (1996). This discussion contains a number of valid and significant points. However, there are several issues which demand amplification or clarification in the light of Woolfe's comments.

Woolfe is quite correct to urge caution in the use of a statistical tool, the QDa–Md method of Buller and McManus (1972), that effectively ignores 50 per cent (the coarse and fine tails) of sediment grain-size distribution data. Whilst it is true that Buller and McManus (1972) suggested that the 16th and 84th percentiles in millimetres (D_{16} and D_{84}, respectively) should be substituted for the quartile values (D_{25} and D_{75}) in order to analyse a greater part of the sediment population, these authors did not in fact adopt such a practice. In establishing their environmental trend envelopes Buller and McManus (1972) found that, in most of the published grain-size data, the values of the quartiles and median grain sizes were readily available, whereas relatively few sources presented the 16th and 84th percentile values. In consequence, Buller and McManus (1972) used the quartiles and medians for their analyses and the establishment of QDa–Md environmental trend envelopes. Indeed, in a suite of subsequent allied studies of the environmental discrimination of turbidites (Buller and McManus, 1973a), pyroclastic deposits (Buller and McManus, 1973b), glacial deposits (Buller and McManus, 1973c), sedimentary rocks (Buller and McManus, 1974), shallow marine deposits (McManus, 1975) and fluviatile sediments (McManus, 1979), the original usage and definition of QDa was maintained. It is therefore not surprising that '... the earlier and more restrictive derivation of QDa ...' (Woolfe, 1996) was retained in my study (Duck, 1994) in order to permit both direct and appropriate comparisons.

I was not attempting in my study (Duck, 1994) to defend the QDa–Md method but rather to test whether it still gives meaningful environmental discrimination of fine-grained sediments when the grain-size

CCC 0197–9337/96/050479–03

distributions had been determined by a modern method, i.e. the SediGraph. When Buller and McManus (1972) established the trend envelope for 'quiet water' deposits they utilized published grain-size data of Shukri and Higazy (1944) and Twenhofel and McKelvey (1939) which had been determined by the pipette method. Having shown in my paper (Duck, 1994) that, in common with other workers (e.g. Welch *et al.*, 1979), the SediGraph records finer median grain sizes than the pipette method, I simply aimed to test whether or not the Buller and McManus (1972, 1973a) Qda–Md trend envelopes for fine materials (quiet water and fluxoturbidite) remain valid for SediGraph data of a suite of fine-grained lacustrine sediments (which had previously been analysed by the pipette method). Indeed, I believe that I was able to show that the envelopes are still valid, despite the considerable differences in the values of QDa and Md recorded.

I am fully aware of the problems involved in applying the QDa–Md method to bimodal and polymodal grain-size distribution data. Nevertheless, despite the general criticisms levelled by Woolfe (1996) and the more focused comments of McArthur (1982), which relate to sediments from alluvial, colluvial and glacial environments, the QDa–Md method has been shown to be a potent means of environmental discrimination. For example, in a comparison of nine bivariate plot techniques (Sedimentation Seminar, 1981), applied to polymodal fluvial materials from the Amazon–Solimões drainage system of Brazil and Peru, the QDa–Md method achieved the highest success rate (86 per cent of samples analysed). Interestingly, the second best method in this study, with had a 56 per cent success rate, was the QDa–Ska method, also introduced by Buller and McManus (1972) but not developed. In common with QDa, the arithmetic quartile skewness parameter (Ska $= [D_{25} + D_{75} - 2\text{Md}]/2$) also ignores 50 per cent, i.e. the tails, of the grain-size distribution curve. The best of the remaining seven bivariate plot techniques achieved a success rate of 36 per cent whilst the poorest was successful to the extent of only 9 per cent in the environmental discrimination of various fluvial deposits (Sedimentation Seminar, 1981).

My reason for focusing attention on the finer-grained deposits was, as stated above, to determine whether or not a modern technique of grain-size analysis (SediGraph) yielded data which are still appropriate for the QDa–Md envelopes established on the basis of the older, pipette method. I chose the SediGraph because both it and the pipette method determine sedimentation diameter through particle settling in accordance with Stokes' Law and the two are therefore comparable (see Duck, 1994). All of the other QDa–Md trend envelopes (e.g. aeolian, beach etc.) for coarser sediments were established on the basis of data derived from sieving, a method which, of course, is still widely used today.

I concede that Woolfe is unhappy with the *methodology* on a broader scale. Indeed there are several methods which have recently developed in response to increased computing power which are perhaps much better able to discriminate between sediment samples from different environments. However, if one accepts that the QDa–Md method is valid then I believe that the *approach* adopted in my comparative study (Duck, 1994) is equally valid.

REFERENCES

Buller, A. T. and McManus, J. 1972. 'Simple metric sedimentary statistics used to recognise different environments', *Sedimentology*, **18**, 1–21.

Buller, A. T. and McManus, J. 1973a. 'Modes of turbidite deposition deduced from grain-size analyses', *Geological Magazine*, **109**, 491–500.

Buller, A. T. and McManus, J. 1973b. 'Distinction among pyroclastic deposits from their grain-size frequency distributions', *Journal of Geology*, **81**, 97–106.

Buller, A. T. and McManus, J. 1973c. 'The quartile-deviation/median diameter relationships of glacial deposits', *Sedimentary Geology*, **10**, 135–146.

Buller, A. T. and McManus, J. 1974. 'The application of quartile deviation–median diameter curves to the interpretation of sedimentary rocks', *Journal of the Geological Society*, **130**, 79–83.

Duck, R. W. 1994. 'Application of the QDa–Md method of environmental discrimination to particle size analyses of fine sediments by pipette and SediGraph methods: A comparative study', *Earth Surface Processes and Landforms*, **19**, 525–529.

McArthur, J. L. 1982. 'Md–QDa characteristics of montane deposits and their confounding of the QDa–Md model for the discrimination of continental environments', *Sedimentary Geology*, **32**, 265–277.

McManus, J. 1975. 'Quartile deviation–median diameter analysis of surface and core sediments from Start Bay', *Journal of the Geology Society*, **131**, 51–56.

McManus, J. 1979. 'The evolution of fluviatile sediments as demonstrated by QDa–Md analysis', *Earth Surface Processes*, **4**, 141–146.

Sedimentation Seminar (Jordan, D. W., Tobin, R. C., Lundegard, P., Samuels, N., Schauf, F., Thaeler, J., VanBeuren, V. and Potter, P. E.) 1981. 'Comparison of methods of size analysis for sands of the Amazon-Solimões Rivers, Brazil and Peru', *Sedimentology*, **28**; 123–128.

Shukri, N. M. and Higazy, R. A. 1944. 'Mechanical analyses of some bottom deposits of the northern Red Sea', *Journal of Sedimentary Petrology*, **14**, 43–69.

Twenhofel, W. H. and McKelvey, V. E. 1939. 'The sediments of Devil's Lake, a eutrophic–oligotrophic lake of southern Wisconsin', *Journal of Sedimentary Petrology*, **9**, 105–121.

Welch, N. H., Allen, P. B. and Galindo, D. J. 1979. 'Particle-size analysis by pipette and SediGraph', *Journal of Environmental Quality*, **8**, 543–546.

Woolfe, K. J. 1996. 'Application of the QDa–Md method of environmental discrimination to particle size analysis of fine sediments—a discussion', *Earth Surface Processes and Landforms*, **21**, 477–478.